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CONTAINER FOR USE IN TRANSPORTING FORENSIC EXPLOSIVE SAMPLES

E. Contestabile, T. Craig and D. Wilson

CANADIAN EXPLOSIVES RESEARCH LABORATORY

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CONTAINER FOR USE IN TRANSPORTING FORENSIC EXPLOSIVE SAMPLES

E. Contestabile*, T.R. Craig**, and D. Wilson***

ABSTRACT

The Canadian Explosives Research Laboratory (CERL) has developed a container for the Central Forensic Laboratory of the Royal Canadian Mounted Police. The purpose of this project was to design a container for shipping explosive-contaminated samples by whatever mode of transportation, including aircraft. To this end, many materials and package configurations were evaluated. The final product accepted for use survives accidental explosions of the samples and fires in the 800°C to 1000°C temperature range for a period of in excess of one hour. The container has been classified under the UN system as 1.4S.

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CONTENEUR POUR L'EXPEDITION D'ECHANTILLONS JUDICIAIRES D'EXPLOSIFS

E. Contestabile*, T.R. Craig**, and D. Wilson***

RÉSUMÉ

Le Laboratoire canadien de recherche sur les explosifs (LCRE) a conçu un conteneur pour le Laboratoire judiciaire central de la Gendarmerie Royale du Canada. Le projet a été entrepris en vue de fabriquer un conteneur destiné à l'expédition, par tout mode de transport y compris les avions, d'échantillons explosifs ou contaminés. À ces fins, plusieurs matériaux et configurations furent évalués. Le produit final approuvé pour cet usage résiste à l'explosion accidentelle des échantillons et à une exposition à des températures de 800°C à 1000°C pendant une période de plus d'une heure causées par le feu. Le conteneur a été classifié 1.4S selon le système UN.

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INTRODUCTION

A request was received by the Canadian Explosives Research Laboratory (CERL) from the Central Forensic Laboratory of the Royal Canadian Mounted Police (RCMP), to design a container for the purpose of transporting small samples of explosives. CERL has experience in this field from designing magazines for the storage of explosives. Containers for transporting explosives and explosive devices were also designed for a private firm (1) and the Explosives Disposal Technology Branch of the RCMP (2).

Due to the nature of their work, the Central Forensic Laboratory chemists, require a container that can be used for shipping explosive calibration samples and explosive-contaminated samples across Canada. For an effective response, the samples must be shipped in the most expediate manner. This may require transport by air, sea or land.

The process of transport subjects explosives to several potentially dangerous situations. The most obvious of these is the collision of the transport vehicle. This action involves low to medium velocity impacts. Also, since most vehicles are propelled by combustible fuels, the risk of a fire is always present. Therefore, in such a situation, explosives must be guarded against impacts and high temperatures. If the action of impact, does not cause the explosive to detonate but a fire ensues, then the container must still provide sufficient protection to allow evacuation of personnel from the danger area.

Based on the above discussion, the container must meet the following basic requirements.

a) The container must endure the physical abuse that may occur during transport.

b) The container must be designed to transport a minimum of five samples, each weighing 10g to a maximum of 50g of any type of explosive.

c) The effects of an accidental detonation of one sample must be completely confined by the container.

d) An accidental detonation of one sample must not communicate and cause the adjacent sample to explode.

e) In case of a fire, the container must provide sufficient time (one hour) to safely evacuate the area and must contain the explosion.

THE FIRE TEST

All the burning trials were performed in the facilities shown in Figure 1. A steel tank 2 m in diameter, 2 m long and having a wall thickness of 2.5 cm is surrounded by 25 cm of reinforced concrete is on its side in an earth mound. In the tank is a steel grating on which the sample being tested is placed. Wood to fuel the fire is placed underneath the grating and on either side of the sample as shown in Figure 2. Since the fire must be maintained for at least one hour and since it cannot be approached to add more wood, an 8 mm copper tube is used to deliver diesel fuel to the fire. The fuel is pumped from the control building to a steel pan placed underneath the grating. Thus, whenever the fire temperature drops, fuel is pumped so as to reestablish the higher temperature.

Stainless stell sheathed thermocouples were used to monitor the fire temperature at the grating just below the sam;e and to monitor the temperature at any other point in the sample. With the aid of a remote video camera, the fire tests are also taped and viewed from inside the control building.

This set-up was found to work very well. It was not difficult to maintain the fire burining for a period of two to three hours and the steel tank retained sufficient heat that no effect was dictated from the changing ambient conditions.

EVALUATION OF MATERIALS AND CONFIGURATION

From previous experience (2), it was decided that the best approach was to use a commercially available vault as the main container. These vaults are already fire rated and drop tested.

Thus, the study began by identifying and evaluating certain materials that would be appropriate for use inside the commercial vault. These materials had to be light, non-combustible, easily machinable and, if

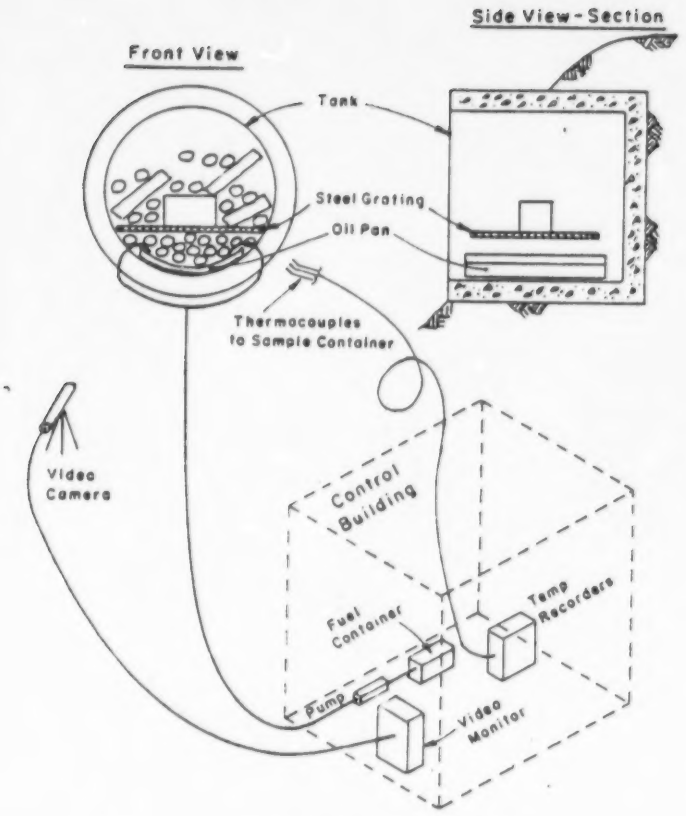


Fig. 1 - Fire test facilities

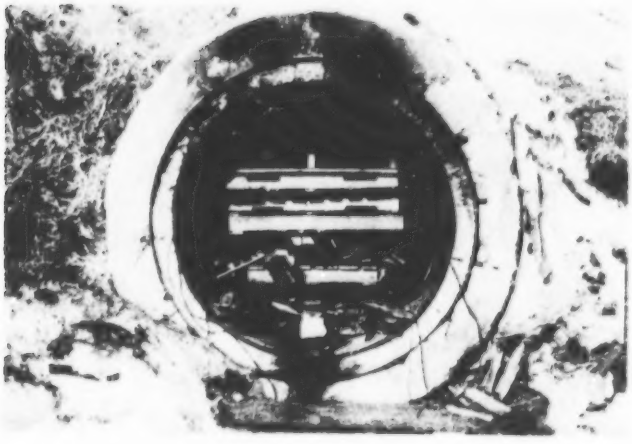


Fig. 2 - Sample container in fire test

possible, good attenuators of shock waves. Specifically, the search concentrated on materials similar to calcium silicate, used in previous containers (2). This led to an investigation of a fairly new line of products made of ceramic fiber and used in the heat intensive industry (ie. refractory).

Ceramic Fiber Materials

The various ceramic fiber products considered were in the form of 25 mm thick boards, having the properties indicated in Table 1 (3). Some of these materials have the appearance of high density foams and can be easily cut with a knife. All of the types tested, S, HS, HS-45 (not listed in Table 1, but similar to others), 2600, and 3000 were of low density and had a high temperature binder.

To determine the effectiveness of these materials to shock energy absorbance, two sample containers were prepared with HS and HS-45. Each container consisted of a 500 ml (12 cm high and 8 cm in diameter) metal can, filled with four layers of the sample material. The top of the can was folded over and a metal lid was secured with duct tape. A hole was then drilled concentrically through the top of the can so that a high strength electric detonator could be placed in the centre of the container. This set-up is shown in Figure 3. When the detonator was fired, the can split open at the seam and the insulation was thrown out. These results are shown in Fig. 4, and Figure 5.

Four more 500 ml containers were prepared using sample materials S, HS, 2600, and 3000. These units were each loaded with a single high strength electric detonator and subjected to the fire test. The fire reached a temperature of about 700°C when the electric detonators began to explode. The times at which this occurred, from the start of the fire test, were 13:52, 14:28, 15:25, and 16:27 minutes. The cans all split open and the insulation completely crumbled.

Calcium Silicate

The above results indicated that the performance of the ceramic fiber material was about equivalent to that of the calcium silicate material

Physical Properties and Chemical Analysis

Physical Properties	M	S	Block	HS	MB-823	MB-830	12C	14C	2600	15C	3000	17C
Thickness, inches (mm)	¼-3" (6.35-76.2)	½-3" (12.7-76.2)	½-3" (12.7-76.2)	½-3" (12.7-76.2)	.125" (3.18)	.15" (3.81)	¼-3" (6.35-76.2)	¼-3" (6.35-76.2)	¼-3" (6.35-76.2)	¼-3" (6.35-76.2)	¼-3" (6.35-76.2)	¼-3" (6.35-76.2)
Color	beige	lt. brown	white	beige	white	tan	yellow	green	blue	lavender	pink	orange
Density, lb./cu. ft. (Kg/m³)	14-16 (224-256)	18-22 (288-352)	18-20 (288-320)	26-30 (416-480)	45 (720)	35-37 (560-592)	14-16 (224-256)	14-16 (224-256)	12-14 (192-224)	11-13 (176-208)	11-13 (176-208)	13-15 (208-240)
Modulus of Rupture lbf/in.² (N/m²)	90-110 ($6.2x10^5$-$7.6x10^5$)	200-230 ($13.8x10^5$-$15.8x10^5$)	220-250 ($15.2x10^5$-$17.3x10^5$)	250-290 ($17.3x10^5$-$19.9x10^5$)	440 ($30.3x10^5$)	—	120-160 ($8.3x10^5$-$11x10^5$)	90-110 ($6.2x10^5$-$7.6x10^5$)	80-100 ($5.5x10^5$-$6.9x10^5$)	70-90 ($4.9x10^5$-$6.2x10^5$)	60-80 ($4.1x10^5$-$5.5x10^5$)	120-160 ($8.3x10^5$-$11x10^5$)
Use Limit, °F (°C)	2300 (1260)	2300 (1260)	2300 (1260)	2300 (1260)	2300 (1260)	2300 (1260)	2200 (1204)	2300 (1260)	2500 (1371)	2700 (1482)	2800 (1538)	3000 (1649)
Chemical Anaylsis %												
Alumina (Al_2O_3)	41.0	48.4	30.6	19.1	30.0	30.0	38.4	46.5	56.0	65.0	75.0	82.5
Silica (SiO_2)	51.2	48.9	69.4	79.7	61.0	55.0	52.5	44.0	38.0	35.0	19.0	17.4
Loss on Ignition (LOI)	4.7	5.8	4.8	4.7	7.2	15.0	9.1	7.9	7.9	7.9	7.9	6.9

Thermal Conductivity (Btu • in./hr. • ft.² • °F)

Mean Temp. °F (°C)	M Board	S Board	HS Board	Expansion Joint Board	Millboard 823	Millboard 830	12C Board	2600 Board	3000 Board
500 (260)	0.47	0.48	0.55	0.43	0.72	0.50	0.45	0.48	0.38
1000 (538)	0.70	0.76	0.70	0.68	0.78	0.73	0.72	0.68	0.54
1500 (816)	1.04	1.14	0.85	0.95	0.85	0.93	1.08	0.95	0.80
2000 (1093)							1.40	1.34	1.19
2400 (1316)								1.80	1.68

Table 1 - Physical properties and chemical analysis ceramic fiber board

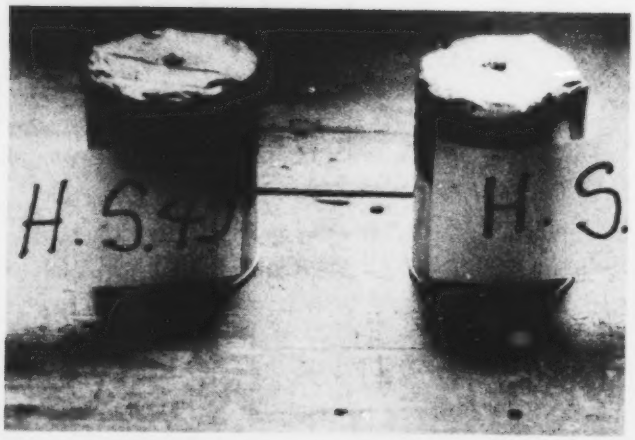


Fig. 3 - Two sample materials in metal can ready for testing

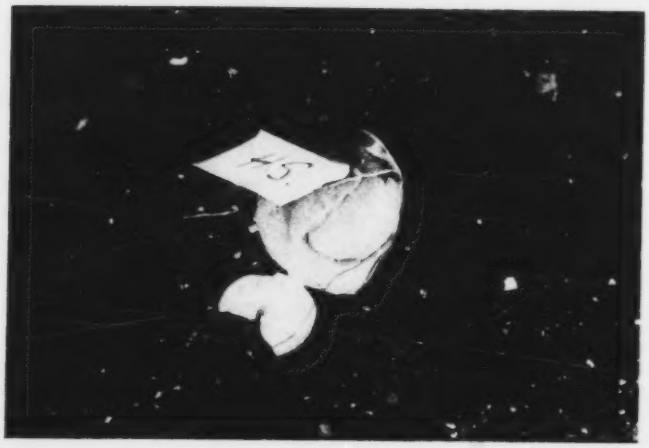


Fig. 4 - Results of shock test on HS sample

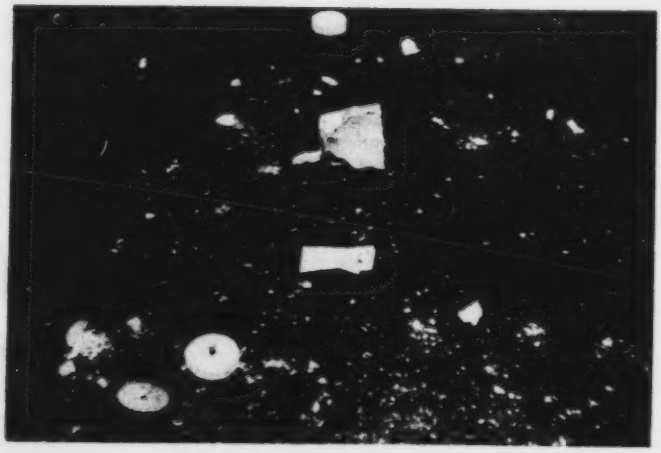


Fig. 5 - Results of shock test on HS-45 sample

in previous studies. Therefore, due to the much higher cost of the ceramic fiber, our attention focused on adapting calcium silicate. Besides the fact that these materials have minimal tensile strength, the calcium silicate also has some inherent problems with regard to machining and handling. It has a tendency to crumble if not handled carefully and of course dusts prolifically. It will be noted in the following tests, that efforts were made to confine the calcium silicate or cover any exposed surfaces to surmount the aformentioned problems.

Initial testing began with a 10.2 cm by 10.2 cm by 7.6 cm block of calcium silicate encased with 12 mm thick plywood. The plywood case was held together with finishing nails. A hole was centrally drilled on one of the 10.2 cm by 7.6 cm sides so as to locate a high strength electric detonator in the centre of the container. On functioning the detonator, the box came apart at the edges. The bottom panel had a small indentation, the closest side panels showed signs of minimal damage while the other two sides and top remained undamaged. The calcium silicate block basically split in two with the upper portion remaining intact while the lower was completely pulverized.

Since the only exposed calcium silicate surface was that in the hole, a similar container to the one described above was constructed to explore the effect of a wooden liner. The hole in the calcium silicate was enlarged to accept a 19 mm diameter hole into which was inserted a wooden dowel that was predrilled to accept an electric detonator. The resulting detonation caused the container to come apart at the edges and flung the mostly pulverized calcium silicate outward. The sides closest to the detonator sustained more damage than in the previous test, with the plywood laminations separating. The sides furthest away from the detonator, including the top and bottom panels were hardly affected. The bottom portion of the wooden dowel was completely consumed whereas the upper portion remained intact.

The following tests were similar to the two just described except that they were designed to explore the effect of a stronger box and whether a detonator could cause another within the same container to function. The first of these containers was composed of a 7.6 cm by 10.2 cm by 19 cm block of calcium silicate encased with 12 mm thick plywood. Four holes were drilled on the centre line and 3.8 cm apart, on one of the 10.2 cm by 7.6 cm sides so as to locate the detonators in the centre of the container.

The box was then nailed together just as in the previous tests but was also bound with two horizontal and three vertical pieces of standard, 10 mm wide, steel strapping. Figure 6 shows a view of this container. One high strength blasting cap was placed in each hole with one of the inside units being wired for initiation. The functioning of this unit did not cause any of the other detonators to be initiated. The sides of the box were only slightly bulged. When the container was disassembled, most of the calcium silicate was found intact except for that in the area where the detonator functioned which had been pulverized.

A similar test was performed with an identical container but with the detonator holes modified to accept a wooden dowel as described in an earlier test. As seen from Fig 7, the resulting detonation caused some damage to the corners of the box and the sides to bulge slightly. No communication occurred, however, the calcium silicate suffered more damage than in the previous test to the extent of causing one of the adjacent detonators to be seized in the dowel.

Considering the fact that the wooden dowel liners were being explosively loaded in a tensile mode, it was decided to test the behaviour of a linen wound phenolic rod which has a much higher tensile strength. The rod was 5 cm in diameter and 7.5 cm long. A 5 cm long hole was drilled along the axis of the rod to accept an electric detonator. This set-up is shown in Figure 8. On detonation, the rod shattered into about twenty pieces.

Commercial vaults

The remaining series of burn trials were performed on commercially available, fire resistant vaults that were modified to accept either high strength electric detonators or small samples of explosives.

The first of these tests was performed on the item shown in Figure 9. It is an insulated filing device (4) classified by Underwriters Laboratories Inc. "As to fire resistance only - rating: 350 -1/2 hr." This means that the paper contents will be protected for one half hour when exposed to a temperature of 925°C (1700°F). The unit is comprised of a top and bottom section with the inside and outside surfaces being made completely of a plastic material. A layer of insulating material containing latent free moisture in crystal form is sandwiched between the

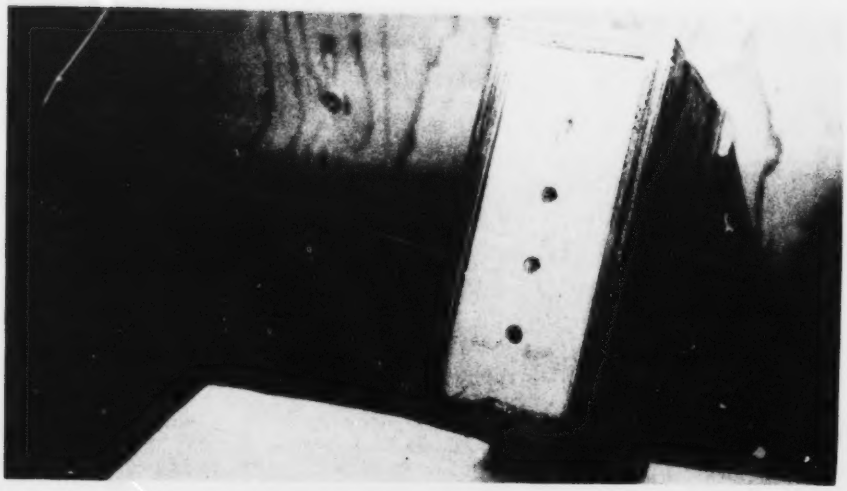


Fig. 6 - Metal-strapped wooden box containing a block of calcium

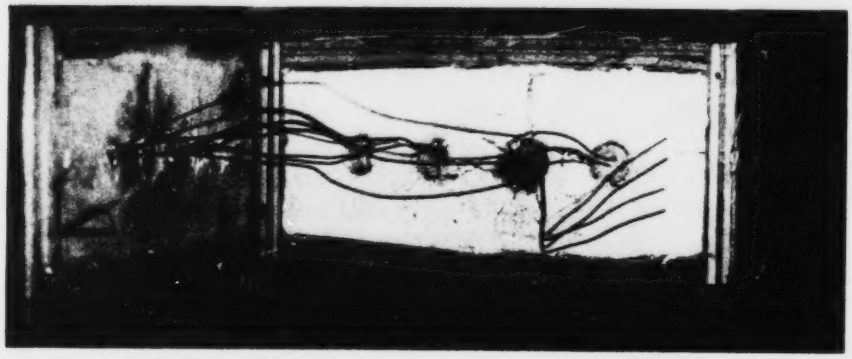


Fig. 7 - Communication test results on a container having wooden dowels

Fig. 8 - Phenolic electric detonator holder

plastic surfaces to provide an effective heat barrier. This container is intended for residential use and is thus not as secure as desired. The inside dimensions are as follows: Height 14.6 cm, depth 18.7 cm, and length 29.8 cm.

A 12.7 cm thick slab of calcium silicate was manufactured to fit snugly into the bottom section of the container. This thickness would give a clearance of about 2 cm when the lid is closed. As shown in Figure 10, the slab had three rows of six holes located 4.2 cm center to center. A 2.5 cm diameter dowel, 10 cm long and pre-drilled to a depth of 7.5 cm to accept an electric detonator, was inserted in each hole. A hole was drilled on the back side of the container and through the calcium silicate block. It was drilled for a stainless steel-clad thermocouple that would be used to monitor the temperature at the center of the calcium silicate block. Figure 11 shows the detonators in place. The container was then closed and due to the rather weak design of the lock it was strapped with two 10 mm wide steel straps.

The container was then subjected to a fire having the temperature profile shown in figure 12. Two of the outer detonators functioned at times of 00:20:16 and 00:20:39 when the fire temperature was about 600°C. At this time the thermocouple within the container was still registering ambient temperature. After the damage sustained, the remaining detonators began to explode at 1:15:36 with the last one functioning at a time of 1:18:01.

The next burning trial was performed on a commercially available metal vault (5) classified by the Underwriters/Laboratories Inc as an insulated record container, Class 350, as to fire resistance only rating: Class 350 - 1 hour. This means that when the item was exposed to a temperature of 926°C for one hour, the interior temperature did not rise above 177°C. The item was also heated to 843°C, then dropped 9 m to rubble of brick and concrete; then cooled, inverted, and reheated to 843°C. The container remained intact and the inside temperature remained below 177°C. In the third test the item was subjected for one half hour to fast fire in a furnace preheated to 1093°C. The container did not sustain any interior or exterior explosion or rupture.

The vault shown in Fig. 13 weighed 25 kg and had the following interior and exterior dimensions, respectively; 14.0 cm H x 33.0 cm W x 42.1 cm D and 25.3 cm H x 40.6 cm W x 31.8 D. The lid had a plastic handle

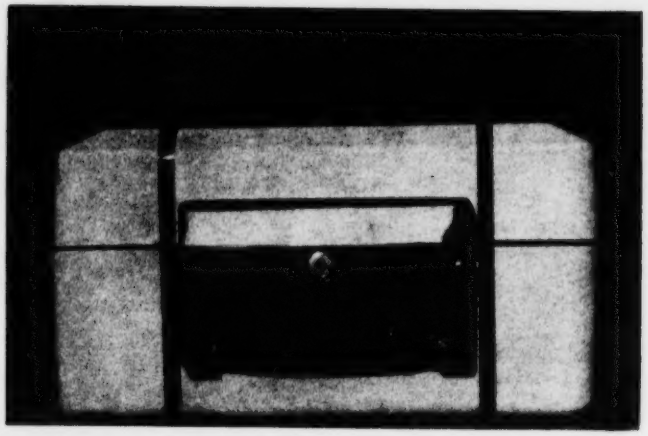


Fig. 9 - Commercial plastic covered vault (steel straps added for burning test).

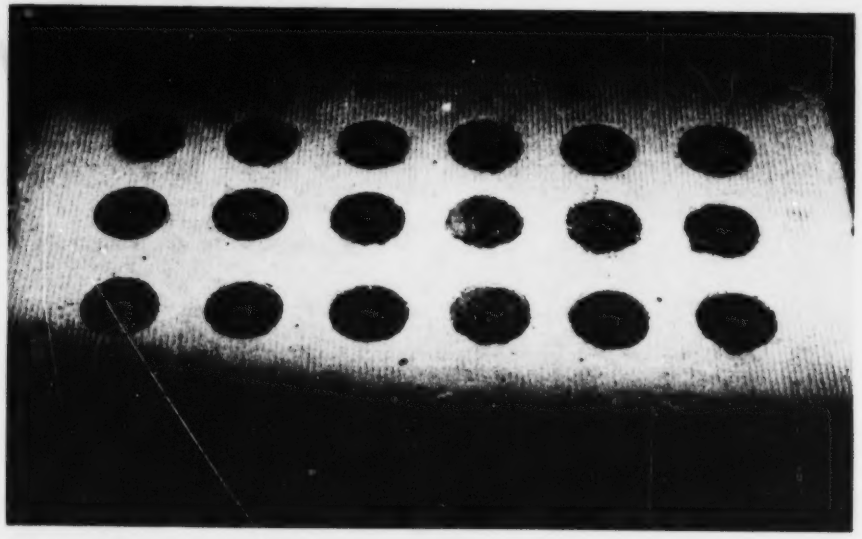


Fig. 10 - Insert for commercial plastic covered vault

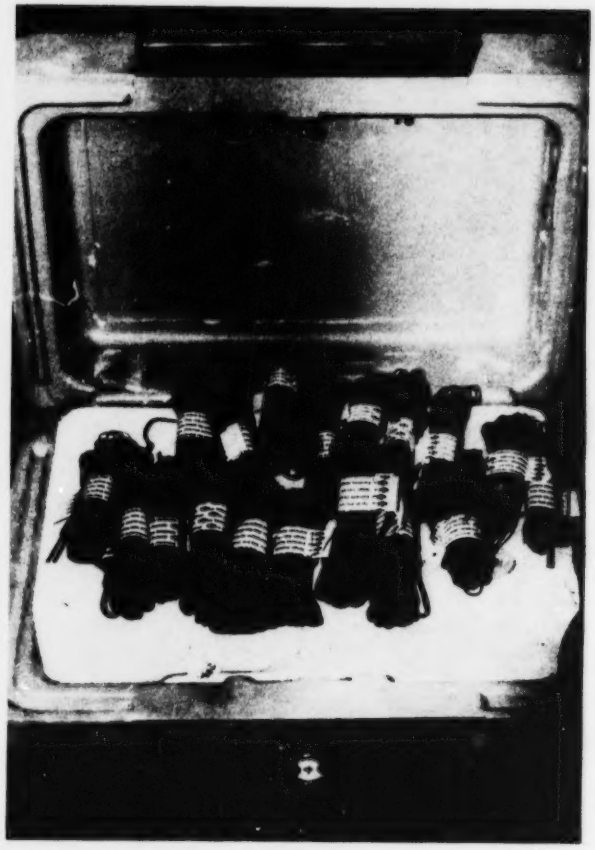


Fig. 11 - Experimental set-up for plastic covered vault burning trial

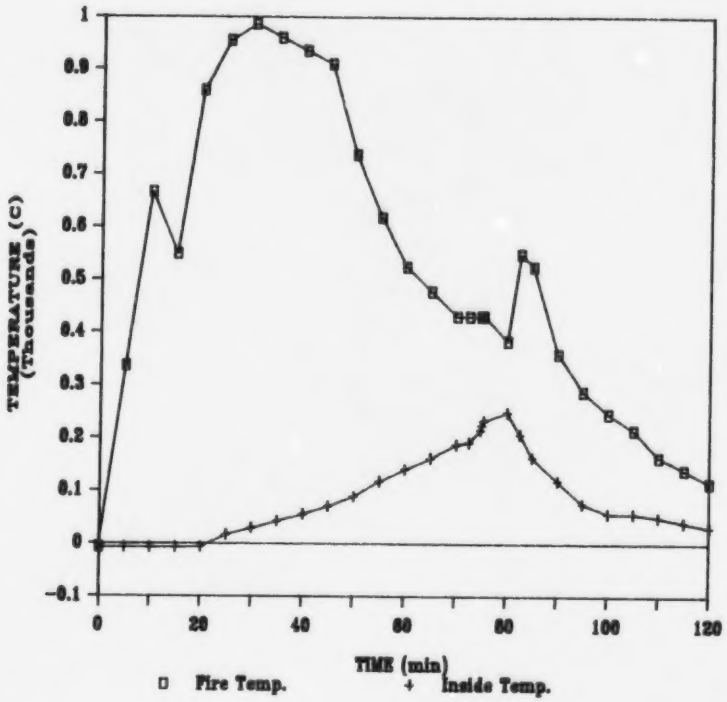


Fig. 12 - Temperature profiles from plastic covered vault burning trial

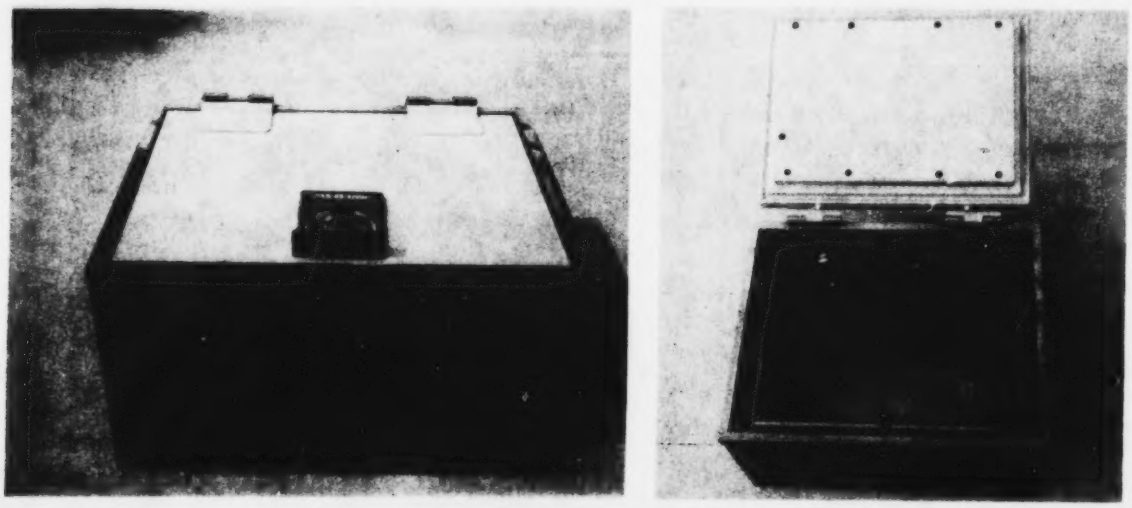


Fig. 13 - Commercial vault

with an integral keyed lock. In preparation for the burn test the vault was modified in the following manner. A 5 cm thick slab of calcium silicate was placed in the bottom of the vault. A second similar piece was drilled in the pattern shown in Figure 14 to accept twelve plastic, 15 cc cream pots having screw-on caps. Finally, a 3.8 cm thick slab was used as the final layer to completely fill the remaining volume of the vault.

Samples of the following explosive materials were used and placed as indicated in Figure 14. Three holes remained empty.

1. Electric detonator (2)
2. Composition C-4 (2)
3. Detonating cord (2)
4. Detasheet (2)
5. RDX (1)

Thermocouples were placed in the vault as indicated in Fig 14, with one being in contact with the RDX container. After being subjected for one and one half hours to a fire in which a thermocouple sensed a temperature in excess of 1000°C, the thermocouples in the vicinity of the samples (TC-3 and TC-4), registered a temperature of 104°C.

On completion of the test, the vault was inspected. The lock had melted and the sides were slightly bulged. The lid was easily opened and the uppermost layer of calcium silicate was removed. From the top, none of the plastic cream pots seemed to have been affected. From the bottom, however, all the plastic containers showed signs of having been distorted from the heat.

None of the samples showed any signs of decomposition. The Detasheet was still pliable and only slightly fused together. The detonating cord, Composition C-4, RDX, and the electric detonator were unaffected.

The above container was used in the following two communication tests. The vault was prepared as in the above fire test and as shown in Figure 15.

In the first communication test, the donor charge was an electric detonator placed in a plastic container in the upper right hand corner. The receptors were an electric detonator and 10 cm of detonating cord, each placed in its own plastic container. Once the charges were in place, the

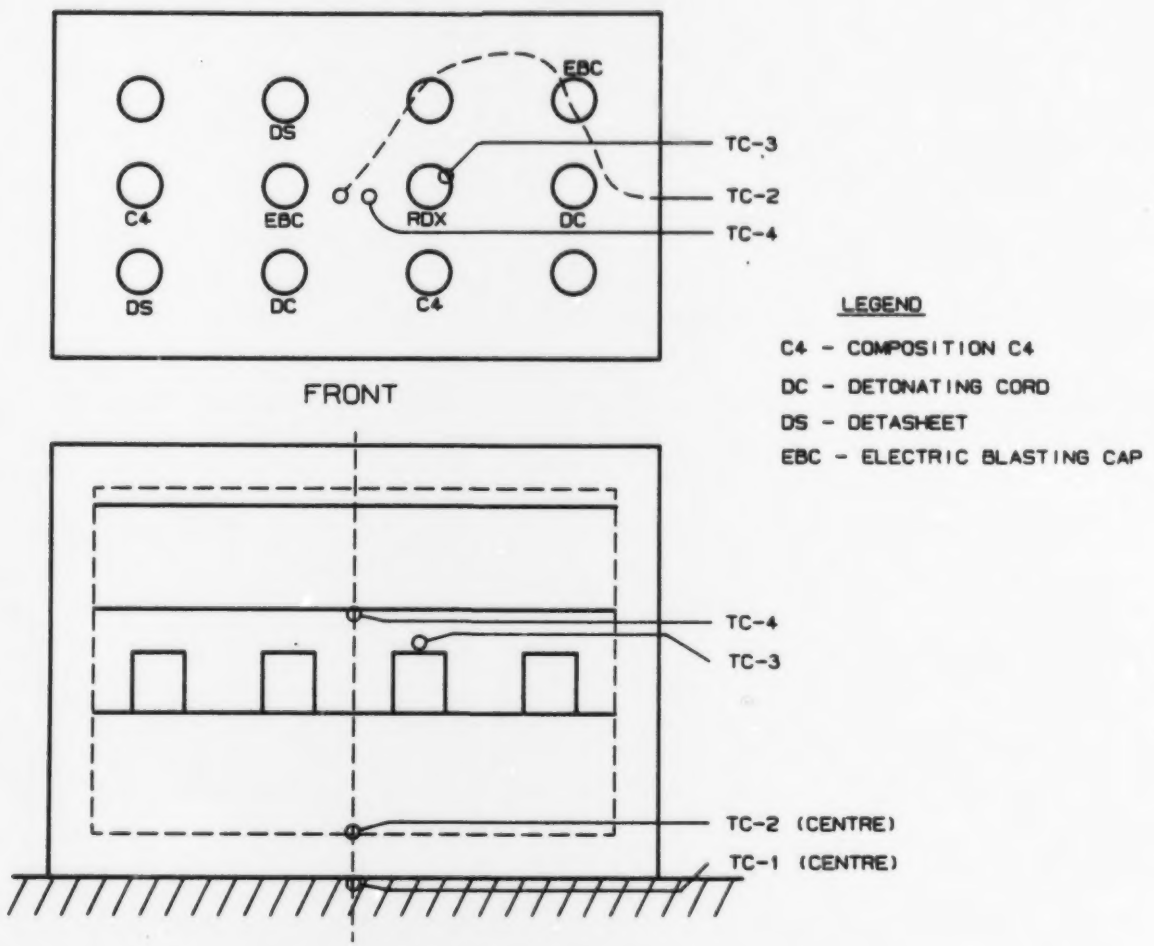


Fig. 14 - Experimental set-up for commercial vault burning trial

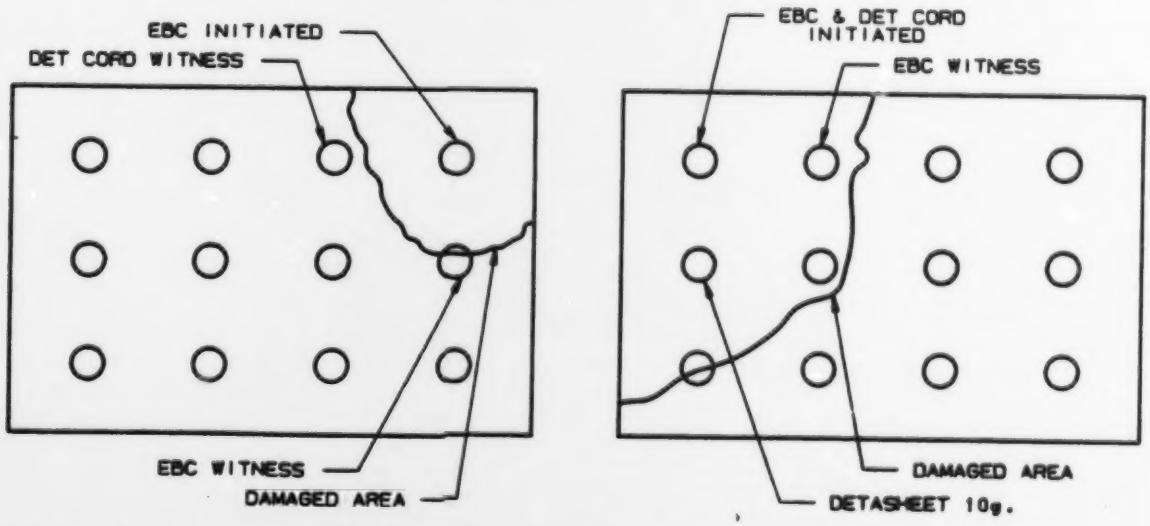


Fig. 15 - Communication test - set-up and damage area

top layer of calcium silicate was added and the vault lid closed. Since the lock was damaged in the fire test, a lead block was used to keep the lid closed. On functioning the donor detonator, a cloud of calcium silicate powder rose from around the lid. Inspection revealed that the top layer was slightly damaged as was the calcium silicate in the vicinity of the donor charge. The donor charge container was destroyed. The vial containing the receptor electric detonator was pushed sideways and split. The detonator was unaffected. The detonating cord container remained intact. The damage area from this test is shown in Figure 15.

The second communication test made use of the upper left-hand side of the vault as viewed from the top. In this test the donor charge was increased, being comprised of an electric detonator and 15 cm of 22 g/m detonating cord in a plastic container. The receptor charges were 10 g of Detasheet and an electric detonator, each placed in is own plastic container. The test was performed as above. Again, on functioning the donor charge, a cloud of calcium silicate dust was ejected from the vault. The top layer of calcium silicate suffered more damage than in the previous test and again there was no sign of the donor container. A large volume of calcium silicate than in the previous test had been pulverized. Both of the other plastic containers had also been shattered but neither the electric detonator nor the Detasheet had been initiated. The extent of the damage to the calcium silicate is indicated in Figure 15.

No damage was sustained by the vault in either of the above two communication tests.

A similar, fire-rated container (7) as the one used in the above tests was evaluated next. This unit weighed 27 kg and had the following interior and exterior dimensions of 27.9 cm H x 40.6 cm W x 20.3 cm D and 36.8 cm H x 46.7 cm W x 27.3 cm D cm thickness of calcium silicate and a single thermocouple was inserted through the side to monitor the internal temperature. A sample of Detasheet, a 15 cm length of detonating cord, and several grams of superfine grade PETN wrapped in a sheet of newspaper were placed in the vault.

The vault was subjected to a fire having a temperature profile similar to that shown in Figure 12. On examining the results, the lock mechanism had melted and the sides of the container were found to be slightly distorted. Once the lid was opened, it was found, that those areas

of the calcium silicate that had been subjected to the higher temperatures had embrittled. The sample sheet of newspaper was completely charred and there was no evidence of the superfine PETN. The PETN from the detonating cord had also decomposed and only the sheathing remained. The Detasheet was unaffected.

The same container was used to perform a communication test. Two layers of calcium silicate, one 5.1 cm and the other 7.6 cm thick were placed in the bottom of the vault. A third, 7.6 cm thick layer was machined as indicated in Fig 16 to hold five plastic sample vials, each filled with 10 g of a dynamite, Forcite 75% (8). An electric detonator was then placed in contact with the centre sample and a fourth, 7.6 cm thick layer of calcium silicate was placed in the vault to complete the unit. Since the lock had been damaged in the burn test, the lid was held closed by strapping the vault with four, 10 mm wide steel straps. The functioning of the detonator caused one of the straps to break and dust to be expelled from around the lid of the vault. The lid opened easily and the top surface of the uppermost layer of calcium silicate was noted to be riddled with minute cracks radiating from its centre. Once removed, the underside of this piece was noted to be cratered to a depth equal to about half its thickness. The center of the stack of calcium silicate layers was also cratered to a depth of 16 cm. There was no communication from the donor charge to any of the witness charges. All four vials were found intact in the bottom of the crater.

A second communication test using the same set-up was performed on a new Meilink vault. This vault was about half the volume of the one used above. The first layer of calcium silicate placed on the bottom was 5.1 cm thick. An electric detonator was imbedded in the center of this slab so as to be flush with its top surface. The next layer was 3.8 cm thick and was machined as indicated in Fig 17 to hold the sample vials. Again, each vial was filled with 10 g of dynamite. A 5.1 cm thickness of calcium silicate was used as the final top layer.

On functioning the detonator, the lid flew open, the vault was thrown in the air, and landed upside down with the lid open. In so doing the hinges were bent and some of the contents spilled out. There was no communication to the other samples nor were the vials damaged. However, the upper layer of calcium silicate was completely destroyed and the other two layers had holes in them. Both, the bottom inside surface of the vault and

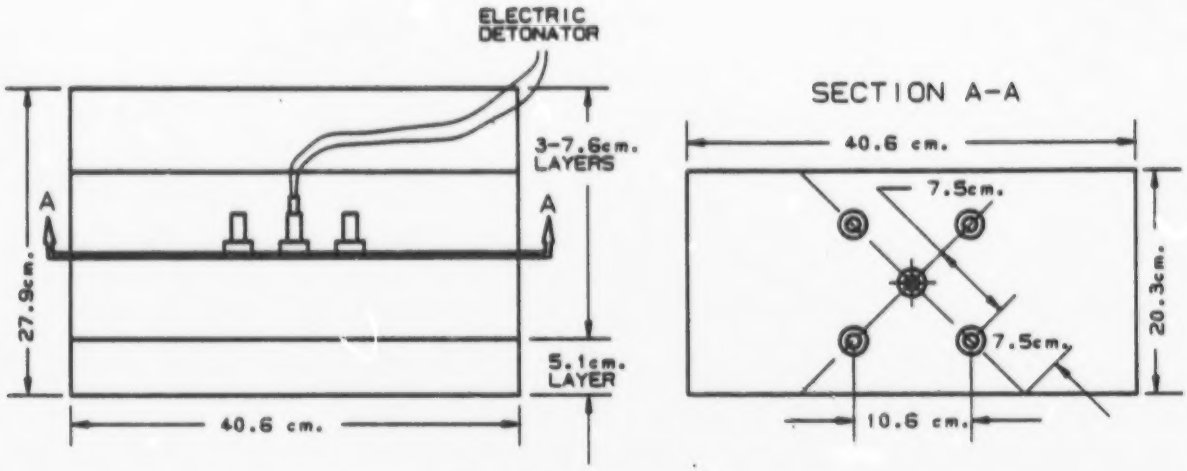


Fig. 16 - Communication test - Gardex vault - 5 samples.

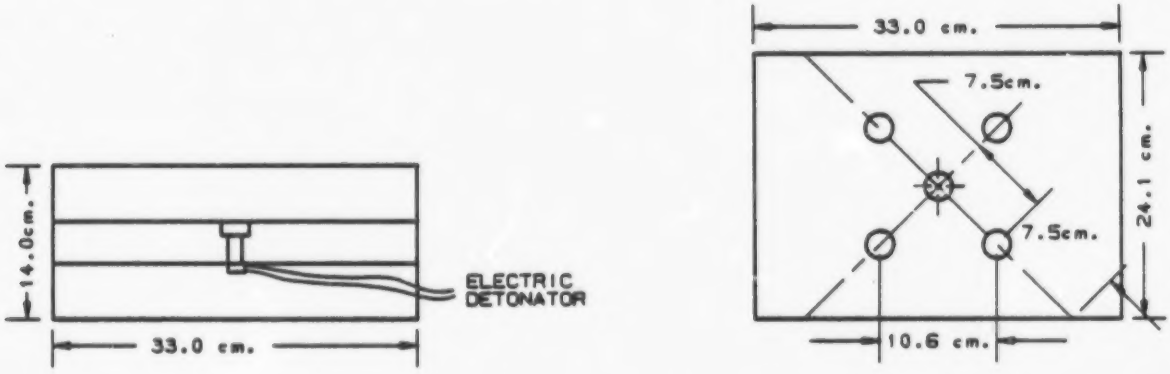


Fig. 17 - Communication test - Meilink vault - 5 samples.

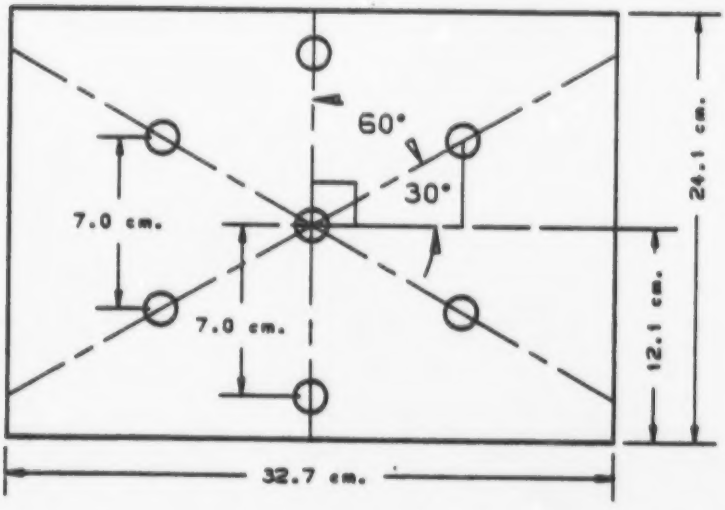


Fig. 18 - Communication test - Meilink vault - 7 samples.

the inside surface of the lid were slightly deformed.

The above container was used in the next communication test to determine what effect an improved locking system would have. The hinges were straightened and a 9.5 mm diameter hole was drilled through both sides of the vault and through the lid so that a steel bar of the same diameter inserted through these holes would hold the lid shut. The communication test set-up was the same as that above except that the 3.8 cm thick, middle layer was machined as shown in Fig. 18 to accept seven sample vials.

After the centrally located electric detonator was functioned, the vault was inspected. There was no perceivable damage to the exterior of the vault. Once opened, it was noted that the inside surface of the lid was slightly deformed and that the top layer of calcium silicate had cracks eminating from the center. Once removed, the underside of this layer was found to be cratered to a depth equal to about half its thickness. The six samples remained intact in their original location around a central crater about 10 cm deep and 8 cm in diameter. As with the lid, the inside surface of the bottom of the vault was slightly deformed.

The above container was next prepared for a burn test with the calcium silicate layers being configured as in the above test. A thermocouple was placed on the center of either side of the bottom layer of clacium silicate. The position of the top thermocouple was such that it was located under the centrally placed sample of explosive. Unlike the previous trials, different samples of explosives were used in this burn test. A sample of each of Composition C-4, RDX, superfine PETN, and Detasheet, and two samples of dynamite (located opposite each other), were placed in the six remaining circumferentially located vials. Once loaded, the vault was locked with the steel bar as in the previous test.

The temperature profiles shown in Fig. 19 indicate that the vault was subjected to a fairly long and hot burn test. The outside of the container was heavily scaled and even slightly perforated at one point of the back wall. The lid could be easily opened once the steel rod was removed but the hinges did show signs of deterioration. When viewed from the top, the calcium silicate located near the back wall, where the heat was most intense, was cracked and crumbling. Once the top layer was removed, it was noted that the seven holes where the vials had been located, were in perfect condition but empty. It seems that the vials and samples of explosive had decomposed leaving only ashes behind. The bottom layer of

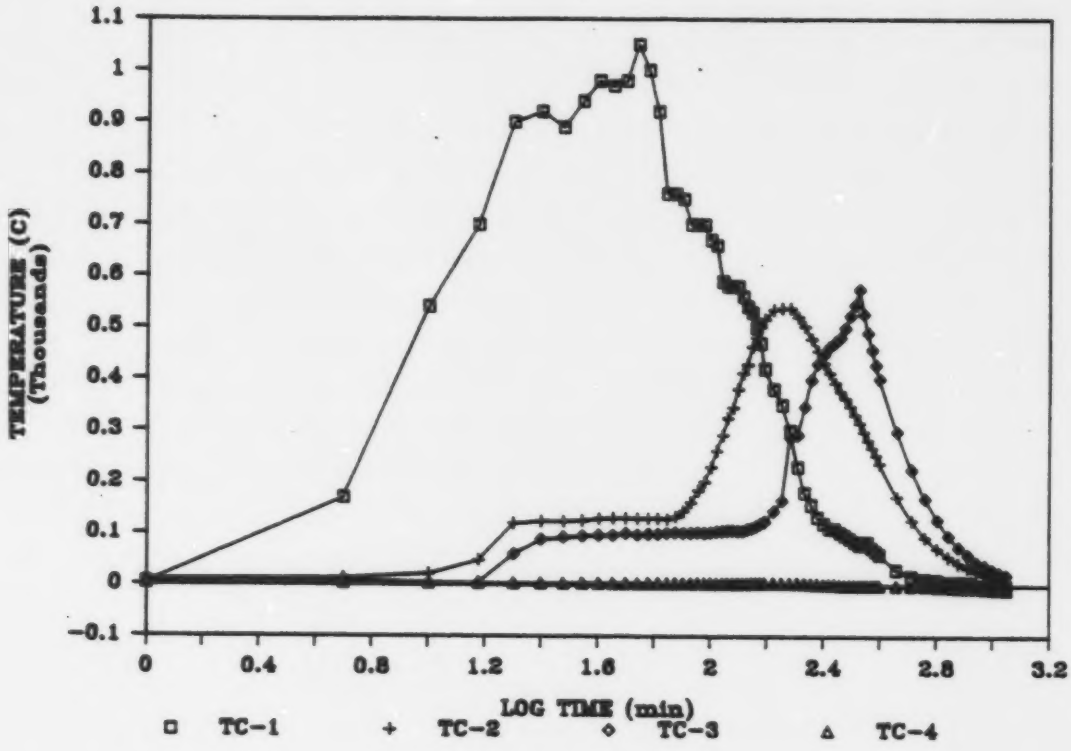


Fig. 19 - Temperature profiles from burning trial on Meilink vault - 7 samples.

calcium silicate also showed signs of excessive heat in the rear area. With this layer removed, the bottom of the vault was observed to have sustained no visible damage.

Fine Tuning the Design

It was evident at this stage that the fundamental concept of the design was sound but required some functional fine tuning. The first problem to eliminate was that of dust from the calcium silicate. In principle, the solution was to simply coat the calcium silicate components with resin and fiberglass cloth. However, this presented many problems. The preparation of the calcium silicate became more critical and the layers had to be glued (9). After preparing several samples, a mixture of resin and chopped glass fibers was used to complete the final design. Included in this design was a bright yellow gel coat and blue straps that served as

handles and held the inner container closed. The sample vials chosen for this final design were 7 ml, Teflon PFA, screw cap containers. As stated in the literature (10), "Teflon PFA main chain carbon-fluorine backbone contains perfluoroalkoxy (PFA) side chains connected through flexible oxygen links. Teflon PFA surpasses any previously available fluorocarbon resin for inertness and mechanical strength at elevated temperatures."

The commercial vault had two weak areas. These were, the small handles and the lock. To circumvent these deficiencies, a carrier was designed. The carrier was basically a hinged steel frame into which fit the commercial vault. The carrier was so designed as to provide large, comfortable handles, two steel latches, and provisions for securing it closed via a padlock.

The procedure for evaluating the finished product was the same as that used on the other containers. Both, communication and burn trials were performed in accordance with the United Nations Test Series 6 (11) as described in Appendix A. The communication trial was set-up as in previous tests, with the centrally located dynamite donor charge being initiated by an electric detonator. The detonator was placed in the vial and dynamite was packed around it. The six receptor charges of 10 g of dynamite were placed in vials in their respective locations around the donor charge. The inner container was held closed with the cloth strap and lowered in the vault. The vault was then locked and placed in the carrier. The lid of the carrier was held closed using the two clasps and a padlock (12) was used to secure it.

A muffled report was heard and whisps of white dust rose from the lid of the vault when the donor charge was functioned. No damage was sustained by the carrier or by the vault. Figure 20 shows the damage to the inner container. There was no communication to the receptor charges. The lower half of the inner container had a hole in its center and the calcium silicate had been pulverized to form a crater. The resin/glass fiber/gel coat top layer had bulged and several cracks radiated from the center hole. The inside surface of the top half also had a hole in it and a small crater. None of the other surfaces showed any sign of damage.

The same carrier and vault were reused for the burn trial. A new inner container was loaded with new vials containing samples of explosives as used in the previous burning trial. A sample of cap grade PETN was placed in the center vial, while one sample each of Composition C-4, RDX,

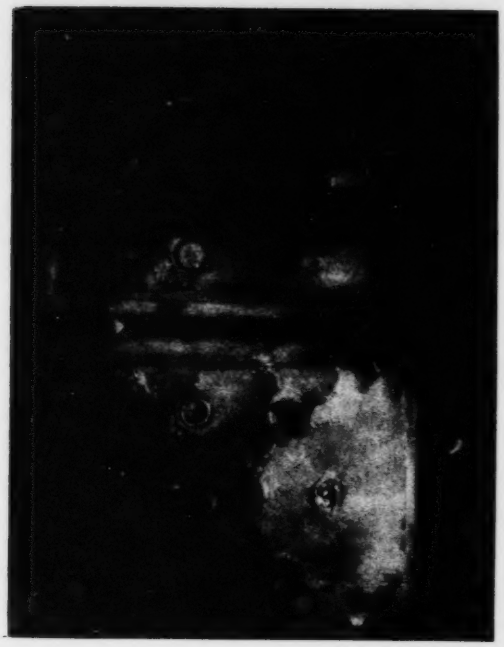


Fig. 20 - Damage to inner container.

superfine PETN, and Detasheet, and two samples of dynamite (located opposite each other), were placed in the six remaining circumferentially located vials. Once loaded, the vault was closed and the carrier lid closed and locked with a padlock.

Four thermocouples were installed within the vault. One was placed in the centre of the bottom of the vault. The other three were placed as indicated in Fig. 21, with thermocouple TC-6 placed under the RDX sample, TC-5 under the Composition C-4 sample, and TC-4 in the calcium silicate.

The assembled container was subjected to a fire test that had the temperature profile shown in Fig. 22, and is labelled TC-2. There was no indication of an explosion during this test. On observing the burned container it was noted that the brass body of the padlock was gone and only the shackle remained. It is postulated that it and the lock mechanism melted. As seen from Fig. 23, the prototype steel carrier was not affected. Except for the melted lock and some scorching, the vault had remained intact. The vault was then opened and the lid of the inner container removed. There was no sign of the vials and the explosive samples had decomposed.

The presence of the resin, glass fibers and gel coat did not seem to have had any adverse reaction. As seen from Fig. 24 the glass fibers

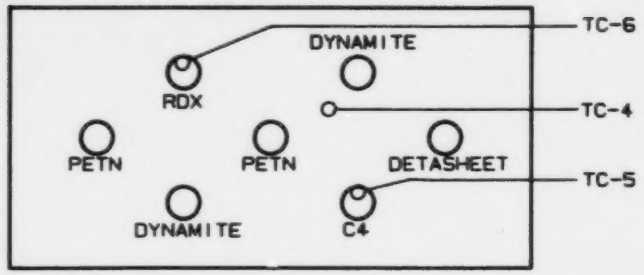
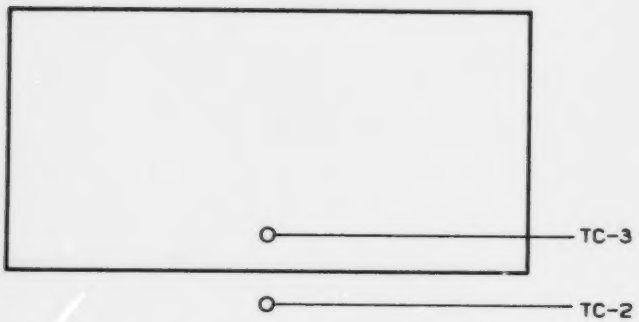


Fig. 21 - Burn trial set-up for explosives container.



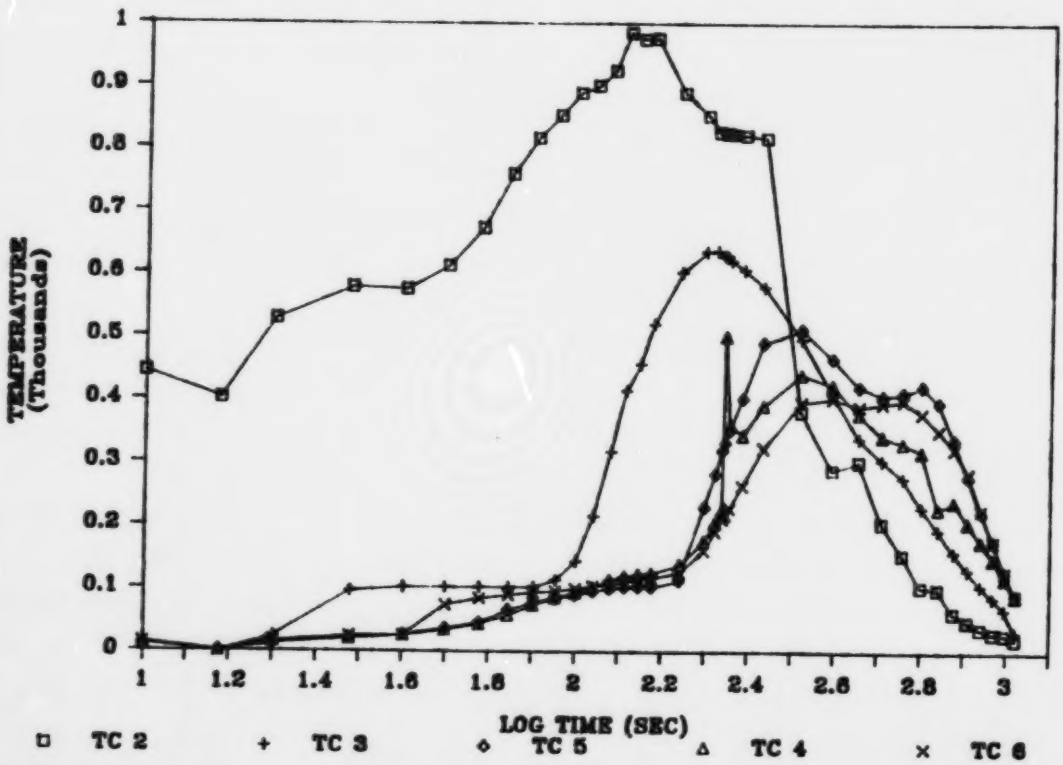


Fig. 22 - Temperature profiles of the burning trial on the explosives container.

Fig. 23 - Explosives container after the burn.

Fig. 24 - Section of inner container after the burn.

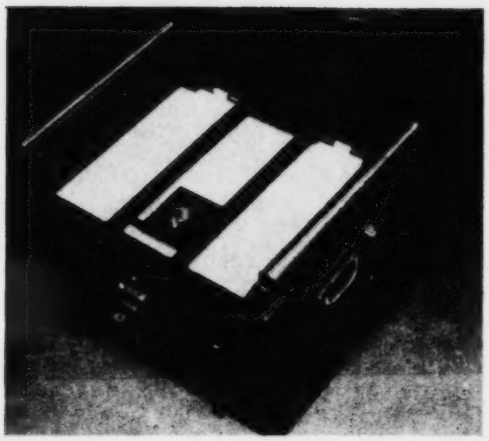


Fig. 25 - Assembled Explosives Container - Forensic.

Fig. 26 - Location of labels.

were still intact and the resin and gel coat were simply charred. From this Figure, it can be seen that the calcium silicate layers had separated at the laminate interface.

The Final Product

Figures 25, 26, and 27, are photographs and Fig. 28, is an assembly drawing of the final product. To ensure proper use of this container, bilingual labels were affixed to the top of the inner container and on the inside surface of the lid of the vault. The label was divided in two areas. The first area was printed in red and labelled "Danger" and listed the "Do Nots". The second area was printed in blue and listed the "Instructions for Use".

RESULTS

The ceramic fiber materials were found to be very easy to work with but they did not seem to be as effective as calcium silicate in the burn or explosion tests. Their high cost was also a factor in negating their use.

Preliminary tests using the simply nailed and steel strapped wooden boxes indicated that the calcium silicate must be sufficiently confined to allow it to absorb the maximum possible energy. The wooden dowels used to line the holes in the calcium silicate were too confining. Their mode of failure, into large pieces, caused the calcium silicate to fracture rather than being pulverized. This failure mode results in more damage since more energy is escaping the containment. The solution was to lightly coat the inside surfaces of the holes in the calcium silicate with abrasive resistant material. This led to completely covering the calcium silicate inner container with a mixture of resin, chopped glass fibers, and a final layer of gel coat. Straps were added to this unit to simplify the assembly of the forensic container.

A tremendous amount of time was saved by sustantiating, through tests, the use of commercial vaults. The shortcomings of these commercial units were simply resolved with the use of the carrier frame. The final

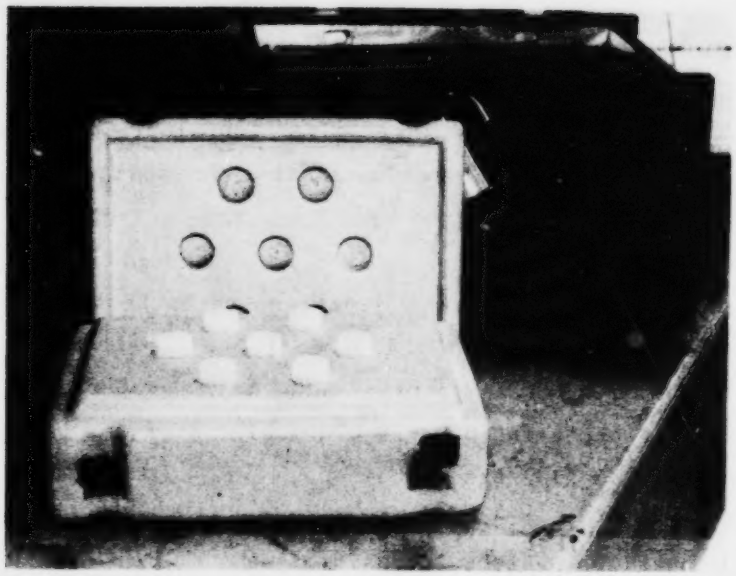


Fig. 27 - Opened Inner Container - Forensic.

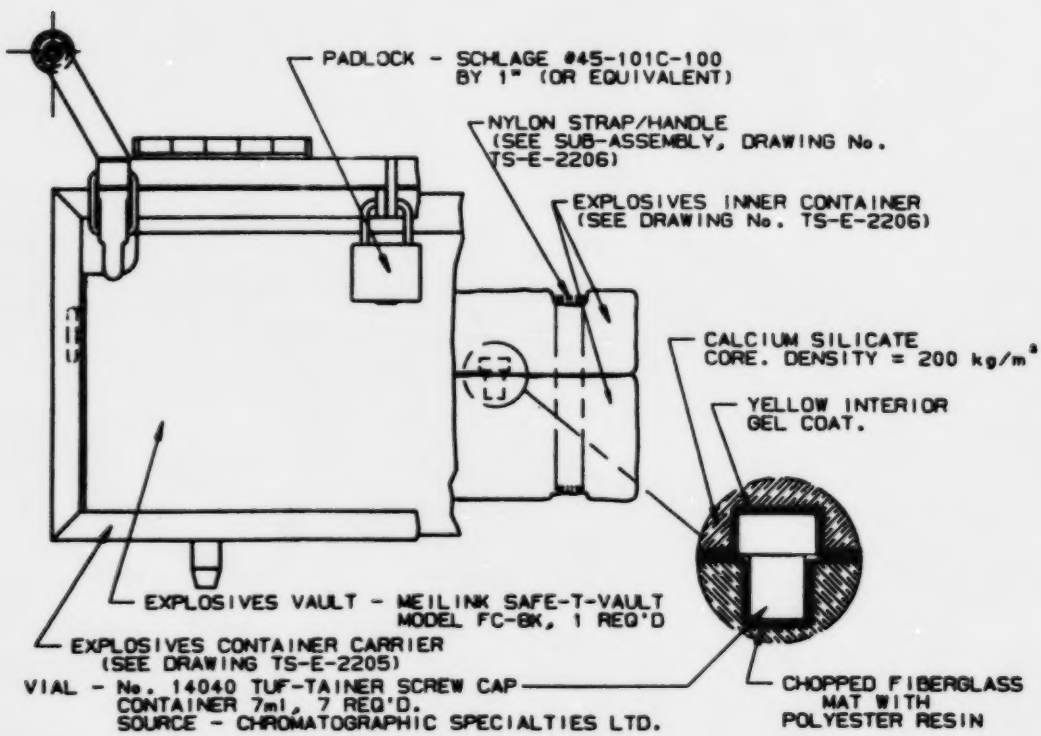


Fig. 28 - Assembly drawing of Inner Container - Forensic

product, "Explosives Container Forensic", has a mass of 35 kg and is comprised of the following components; /Inner Container-Forensic/, /Explosives Vault-Forensic/, and /Explosives Container Carrier-Forensic/.

As named, the Explosives Container - Forensic, has been evaluated using the U.N. Test series 6(a) and 6(c). With a variety of explosives, no communication was observed and only minor effects were observed outside the container (6(a) Test). In the 6(c) Test, no detonations were obtained and there were no effects outside the container. As a result this container appears suitable for transporting explosive substances of unknown properties; and, in the event of an accidental explosion, only minor effects would be observable outside the container.

The container was thus classified as:

U.N. Class 1.4 Compatability Group S
U.N. Number 0445
U.N. Name CHARGES, EXPLOSIVE, COMMERCIAL

ACKNOWLEDGEMENTS

The authors wish to acknowledge the contributions of CERL staff member R.A. Augsten, who aided in the video taping and data recording and CERL Manager R.R. Vandebeek, for assisting to bring this container into production. Members of the Technical Services Division must also be thanked. D. Norman for ensuring that proper drawings were made and for contracting the manufacture of the containers, E. Sickman and R. LaFrance for designing and building the prototype carriers, and D. McIntosh for the drawings appearing in this report.

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2. Contestabile, E., T.R. Craig, and J.A. Doucette, "Portable containers for transporting explosives by air, sea and land", Mining Research Laboratories, Report No. ACEA/MRL 83-2 (TR), 1983.

3. Kaowool ceramic fiber boards are products of Babcock & Wilcox, Insulating Products Division, Augusta, Georgia, USA.

4. Plastic covered vault, Chubb Fire Security, 777 Dundas St. East, Toronto, Ontario, M4M 1P9.

5. Meilink vault, Meilink Safe Company, P.O. Box 2458, Whitehouse OH, 43571.

6. Detasheet is a product of E.I. Du Pont de Nemours & Co. (Inc.), Explosives Products Division, Military Specialty Sales, Wilmington, Delaware 19898.

7. Gardex port-a-file, Gardex, 41 J.F. Kennedy Blvd, St. Jerome, Quebec, J7Y 4B5.

8. Forcite 75% is a product of CIL Inc., McMasterville, Québec.

9. Foster adhesive 81-27, Manufactured by Mulco Inc., and Distributed by Insul-Coustic Inc., 2766 Fenton Rd., Gloucester.

10. Tuf-Tainers Teflon (PFA) vials were obtained from Chromatographic Specialties Inc., P.O. Bag 1150, 300 Laurier Blvd., Brockville, Ontario.

11. Recommendations on the Transport of Dangerous Goods, Tests and Criteria, First Edition, United Nations New York, 1986. ISBN 92-1-139021-4.

12. Padlock required - Schlage #45-101C-100 by 2.5 cm (or equivalent).

APPENDIX A

United Nations Test Series 6

The full details of these tests are given in reference (11) in the bibliography. What follows is an excerpt from Reference 11. It is a brief definition of the three types of tests that are performed in Test Series 6 for the purpose of assigning a product to a hazard division and a compatability group.

(a) Test Type (a) (single package test): A test on a single package for the purpose of determining:

  (i) Whether initiation or ignition in the package causes burning or explosion and whether burning or explosion is propagated in the package; and
  (ii) In what way the surroundings could be endangered by these effects;

(b) Test Type (b) (stack test): Test on a stack of packages of an explosive product or a stack of non-packaged explosive articles for the purpose of determining:

  (i) Whether burning or explosion in the stack is propagated from one package to another or from a non-packaged article to another; and
  (ii) In what way the surroundings could be endangered in this event;

(c) Test Type 6 (c) (external fire test): Test on a stack of packages of an explosive product or a stack of non-packaged explosive articles for the purpose of determining:

  (i) How the packages or non-packaged articles in the stack behave when involved in an external fire simulating a realistic accident; and
  ii) Whether, and in what way, the surroundings are endangered by blast waves, heat radiation and/or fragment projection.